Suspended gold particles with magnetic cores for in vitro diagnostics

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One method for reducing the complexity of sample preparation in *in vitro* diagnostic platforms is to use magnetic particles, functionalized with an antibody to the analyte (drug, hormone, pathogen, etc), to sweep the sample. The particles collect the analyte and can then be separated from the sample using a simple magnetic field. This approach allows for sample cleanup by rinsing and for concentration of the analyte prior to analysis. Generally, these magnetic particles are spherical in shape, and are made of polymer impregnated with magnetic nanoparticles or of the magnetic material itself. In this work, we are developing lithographically-defined magnetic core particles whose shape can be tailored to increase the effective surface area or to contain specific optical properties, and whose physical makeup can be altered in the fabrication sequence.

We use ion-beam proximity lithography as a method for forming large-areas of periodic structures with high throughput, although any number of lithographic techniques could be employed. The fabrication sequence is shown schematically in Figure 1: (a) a wafer is coated with a 800nm thick layer of poly(methyl glutarimide) (PMGI) and a 50nm thick layer of poly(methyl metchacrylate) (PMMA) by spin-casting and the desired particle pattern is printed using ion beam proximity lithography. (b) The pattern is developed using a 3:1 solution of IPA:MIBK and the PMGI is etched partially using a 2.3% solution of TMAH in water. (c) The particle material is deposited by evaporation; in our case, we use alternating gold (20nm), permalloy (Fe:Ni) (20nm), and gold (20nm) layers. (d) An acetone lift-off step dissolves the PMMA layer and (e) the remaining particles are released and suspended into the TMAH solution. These particles can readily be concentrated and rinsed by applying a magnetic field and the solution can be exchanged.

Our first results are shown in Figure 2, where 5x5x0.06 μm^3 squares are dried on a silicon substrate and imaged using an SEM. Although these structures are too large to have interesting nanoscale optical properties, they do show that the process works well. Vibrating sample magnetometry measurements of the patterned sample reveals that the magnetic layer retains residual magnetism and therefore the structures are attracted to each other in solution. However, the high pH of the TMAH solution (13.7) charges the gold surface sufficiently so that the particles repel each other and they remain isolated structures in solution. One can observe a sudden clustering of the particles as the pH of the solution is lowered.

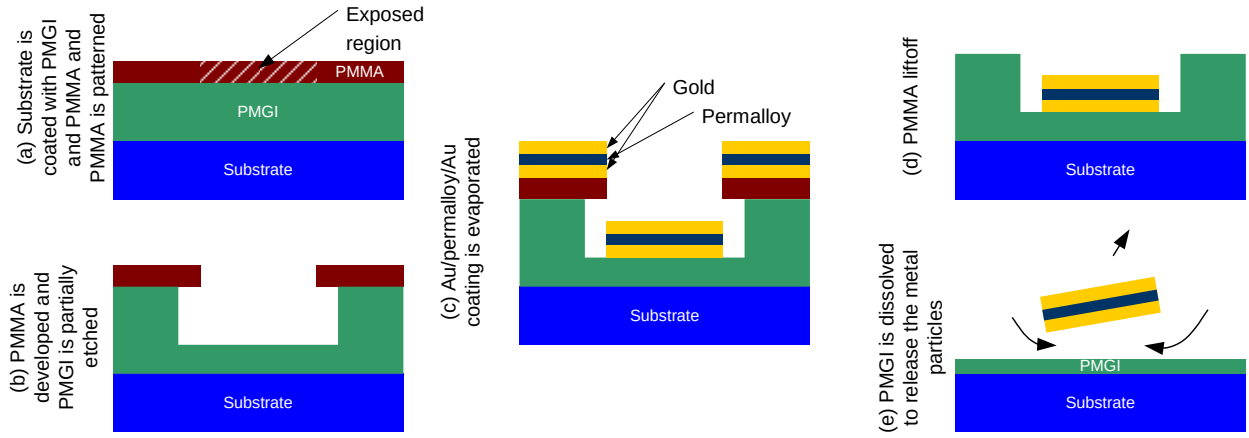

Figure 1: Fabrication sequence

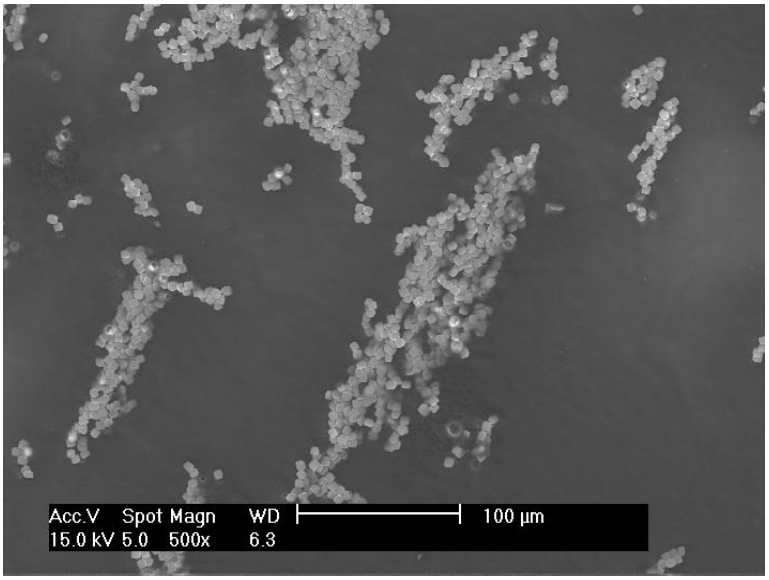

Figure 2: Gold particles with permalloy cores dried on a silicon substrate.

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